Preparation for MHD Testing

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M. Ulrickson
ALPS Meeting
La Jolla, CA

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy under contract DE-AC04-94AL85000.

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Outline

- LIMITS – LIquid Metal Integrated Test System
- Magnetic Fields in NSTX (new cases)
- Magnet Design
- Status of Fabrication

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Laboratory Studies of MHD Effects

- Because of the urgent need for experiments to validate the MHD modeling of flowing free surface liquids, we have constructed two new experimental devices (LIMITS and MTOR)
- MTOR is a toroidal coil facility constructed from the TARA coils. Initial experiments on liquid Ga have started in the last month at UCLA.
- LIMITS is a permanent magnet system with flowing Li at Sandia. Experiments will start within the next month.

New LIMITS

- Liquid Metal Integrated Test System
- 15 gpm liquid metal flow loop
- Test chamber with either magnet system for MHD testing or electron beam for HHF testing.
- All hardware completed and final commissioning in progress.
- Full diagnostics set: flow, delta P, delta T, surface T, etc.

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LIMITS

- LIMITS pump mounted on the furnace for melting Li
- Furnace heaters are mounted
- Temporary flow lines are attached for flow testing of the pump
- The cooling lines for the motor are not connected in this photo

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New NSTX Plasma Equilibria

- Two cases were provided by Bob Kaita
  - Lower single null, low beta plasma
  - Lower single null, high beta plasma
- General observations
  - X-point and strike point move outward slightly as beta increases (few cm)
  - Even the 10 cm flux surface fits easily on the outer divertor plate
  - There is room for both nozzles and catchers

Magnetic Fields in NSTX (new cases)

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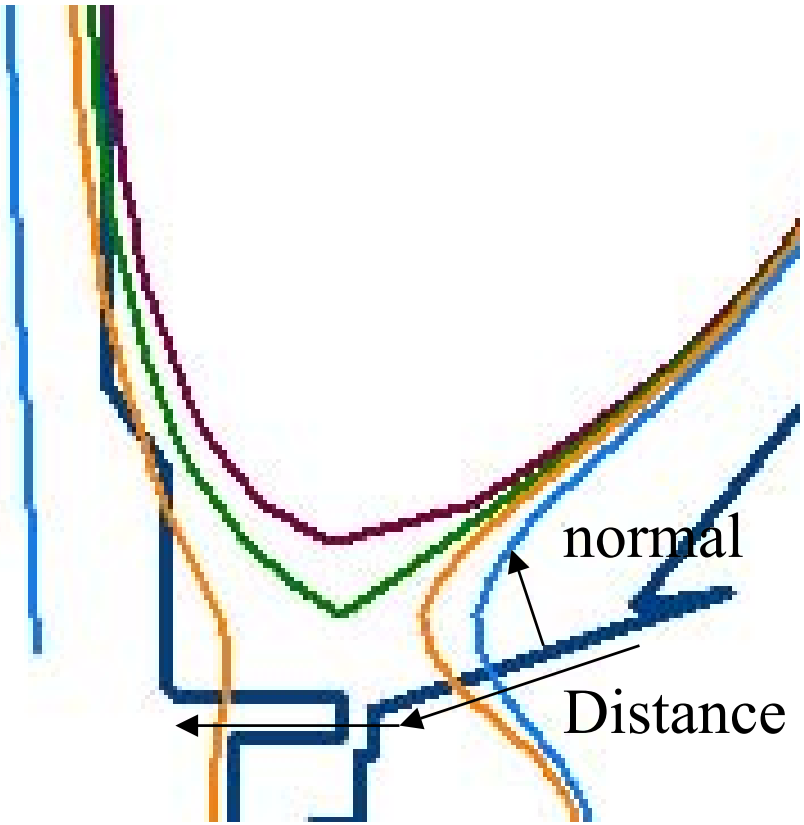
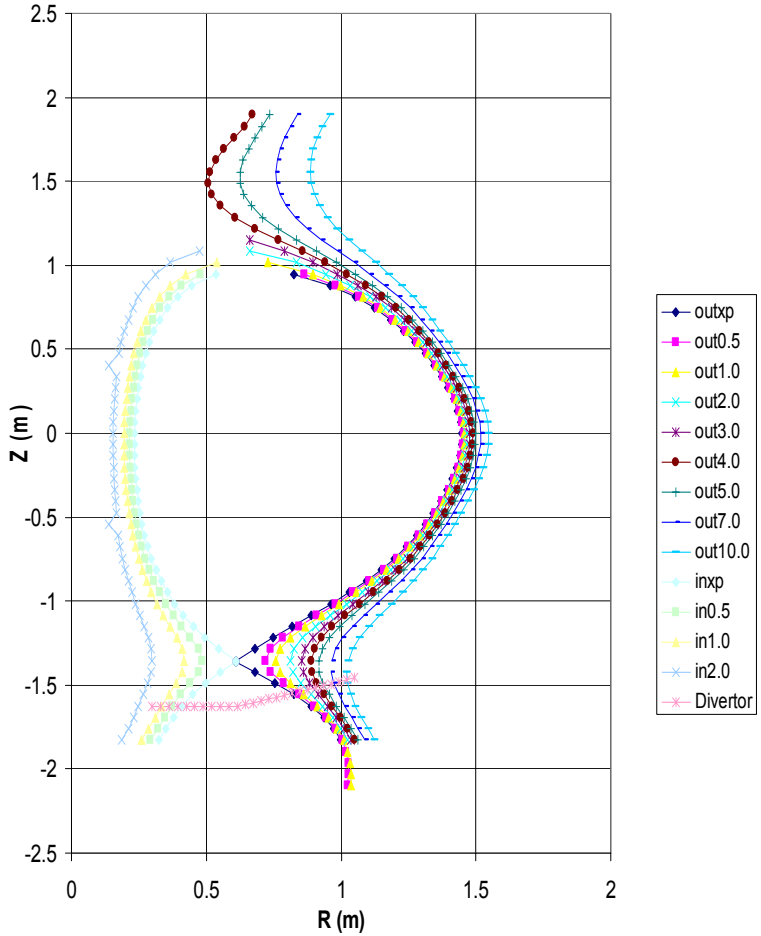
NSTX Divertor Plate Detail



- Distance is measured from the outside toward the inside along the divertor plate.
- The surface normal to the divertor plate is calculated from the shape of the plate.

Field Line Plot High Beta

- The upper x-point is substantially outside the lower x-point
- This plot does not have the same scale on both axes
- This information will be posted on the Sandia FTP site.



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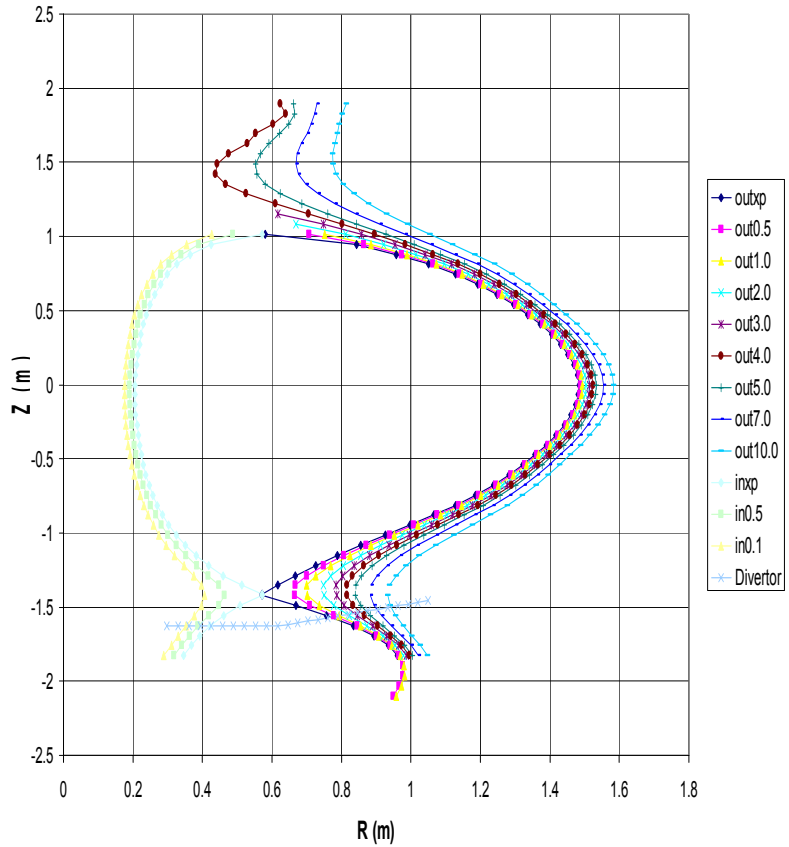
Field Line Plot Low Beta

- **Note the field lines in the divertor region are closer together than for the high beta case.**



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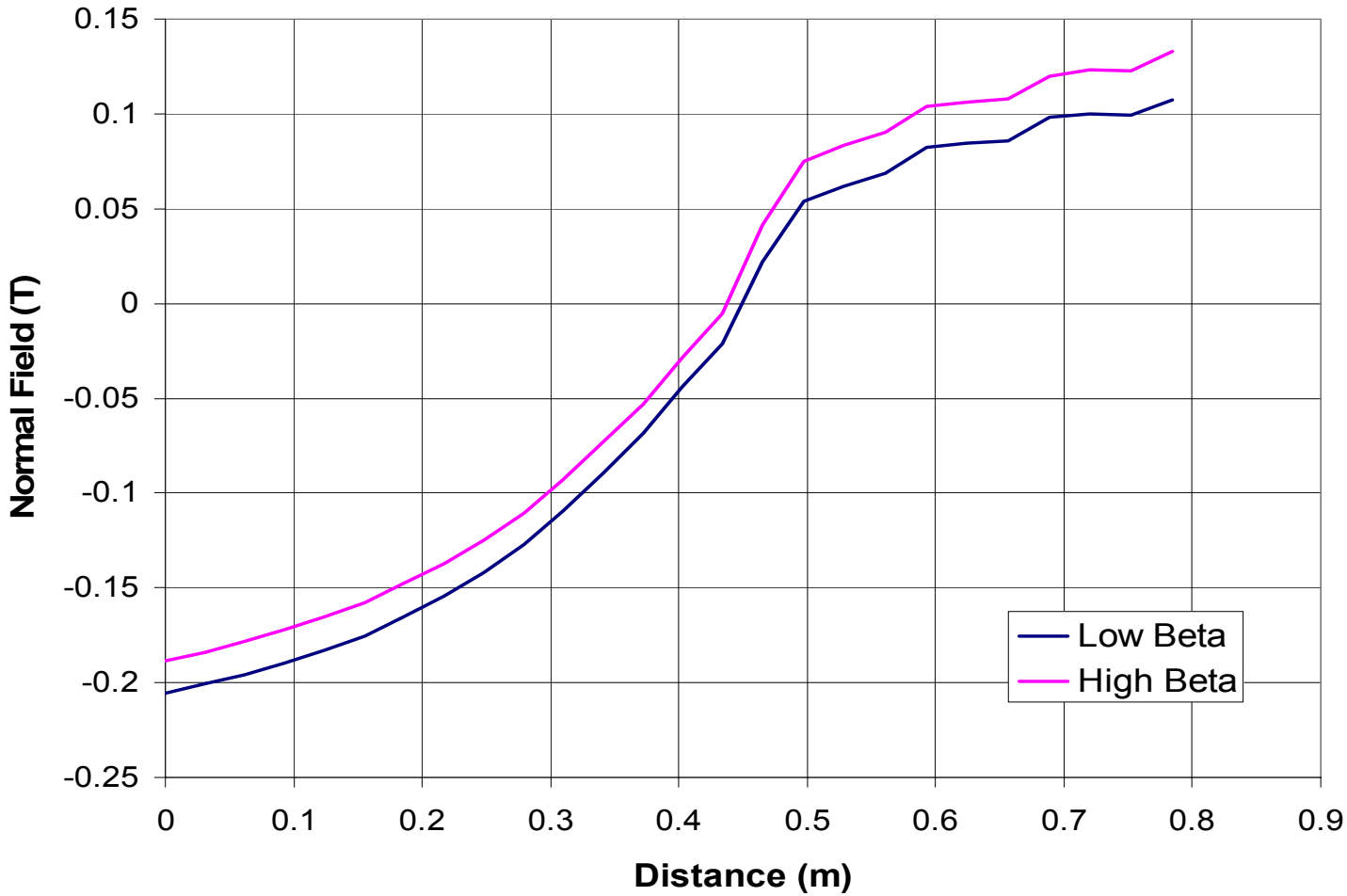
Poloidal Field Normal to Flow



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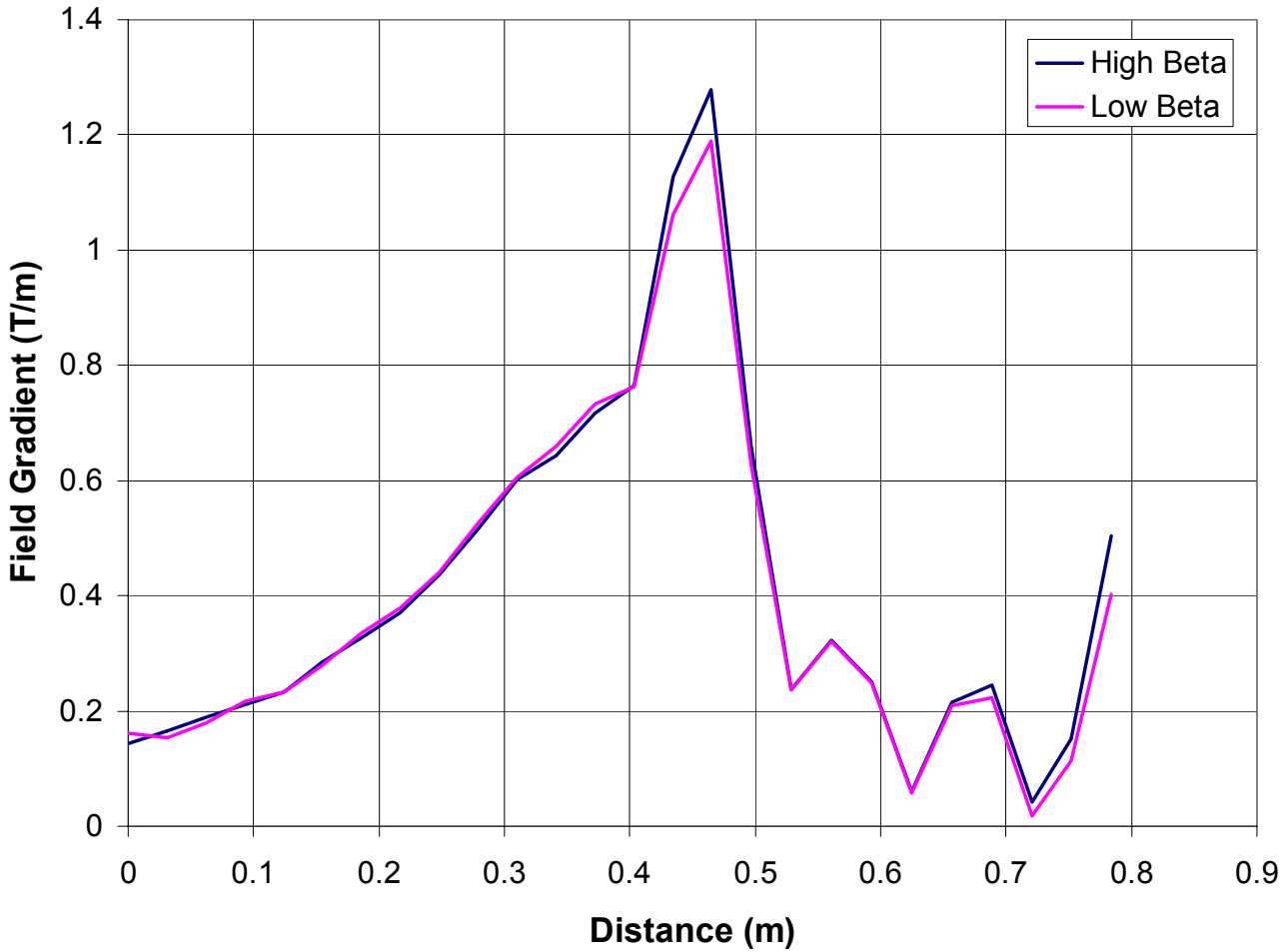
Gradient of Normal Field Component



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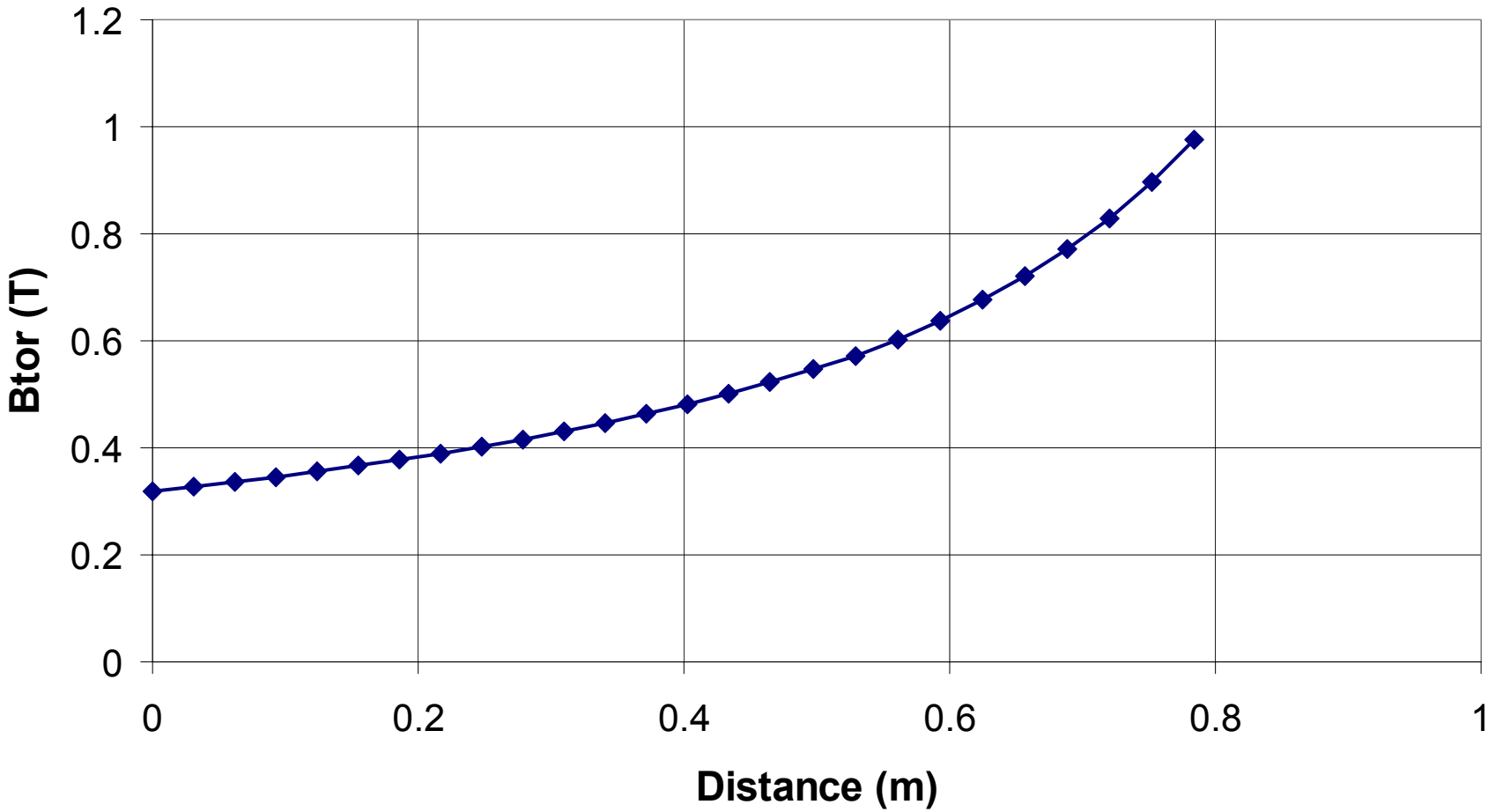
NSTX Toroidal Field at Divertor



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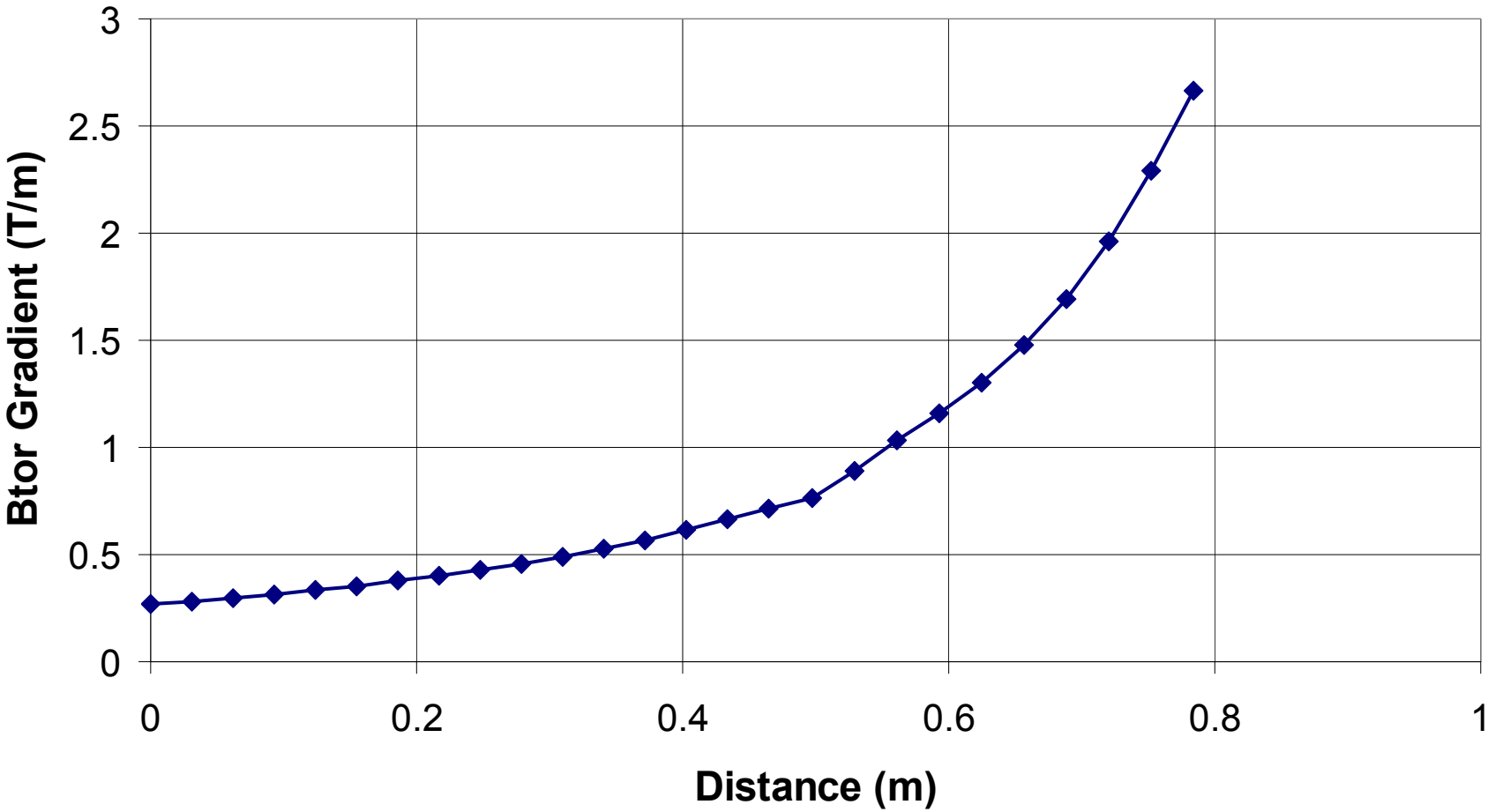
NSTX Toroidal Field Gradient (Divertor)



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Magnet Design

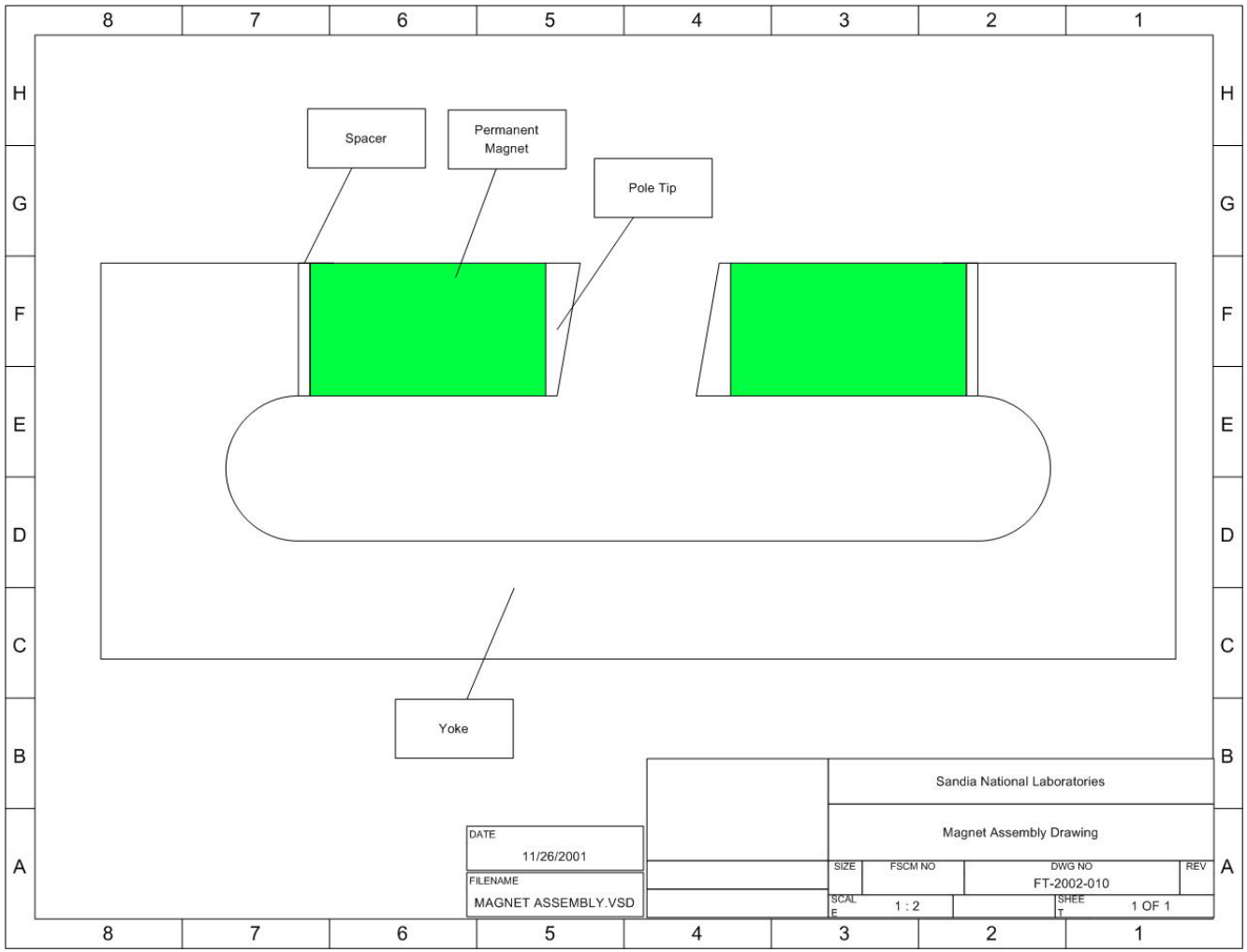
Magnet Design

- An iron yoke magnet was designed with replaceable pole tips to allow a range of field configurations was designed.
- The basic features of the design are shown in the next slide.
- The magnet is compatible with the LIMITS chamber.

Analysis Of Magnet Geometry

- The code PC Opera was used to design the shape and spacing of the magnet to be used for MHD studies
- The field strength in the gap was computed for a range of magnet gaps and tilt of the pole faces (the geometry is shown in the next figure).
- The correlation of field strength with geometry was determined.
- The gap and angle needed to reproduce the NSTX fields are varied along the depth of the magnet.

Magnet Design For MHD Testing



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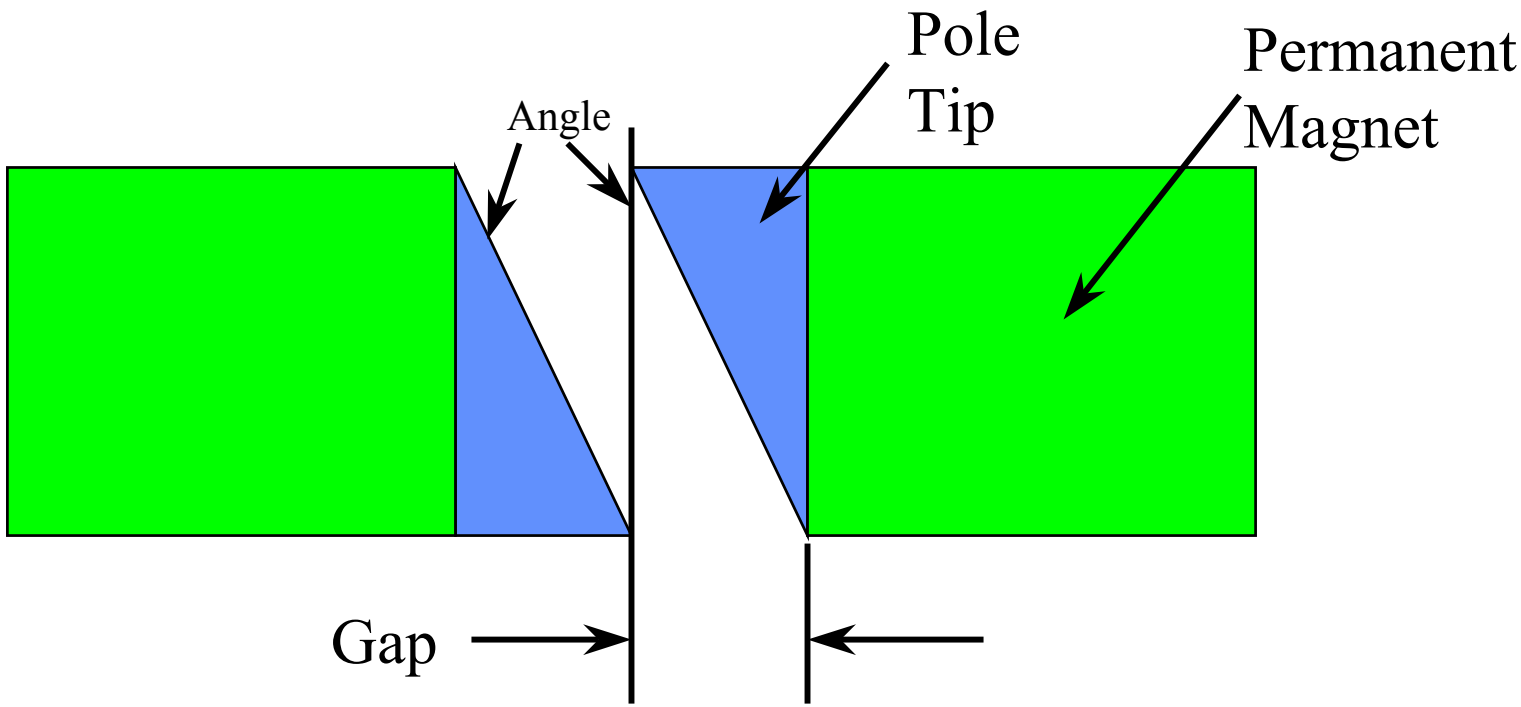
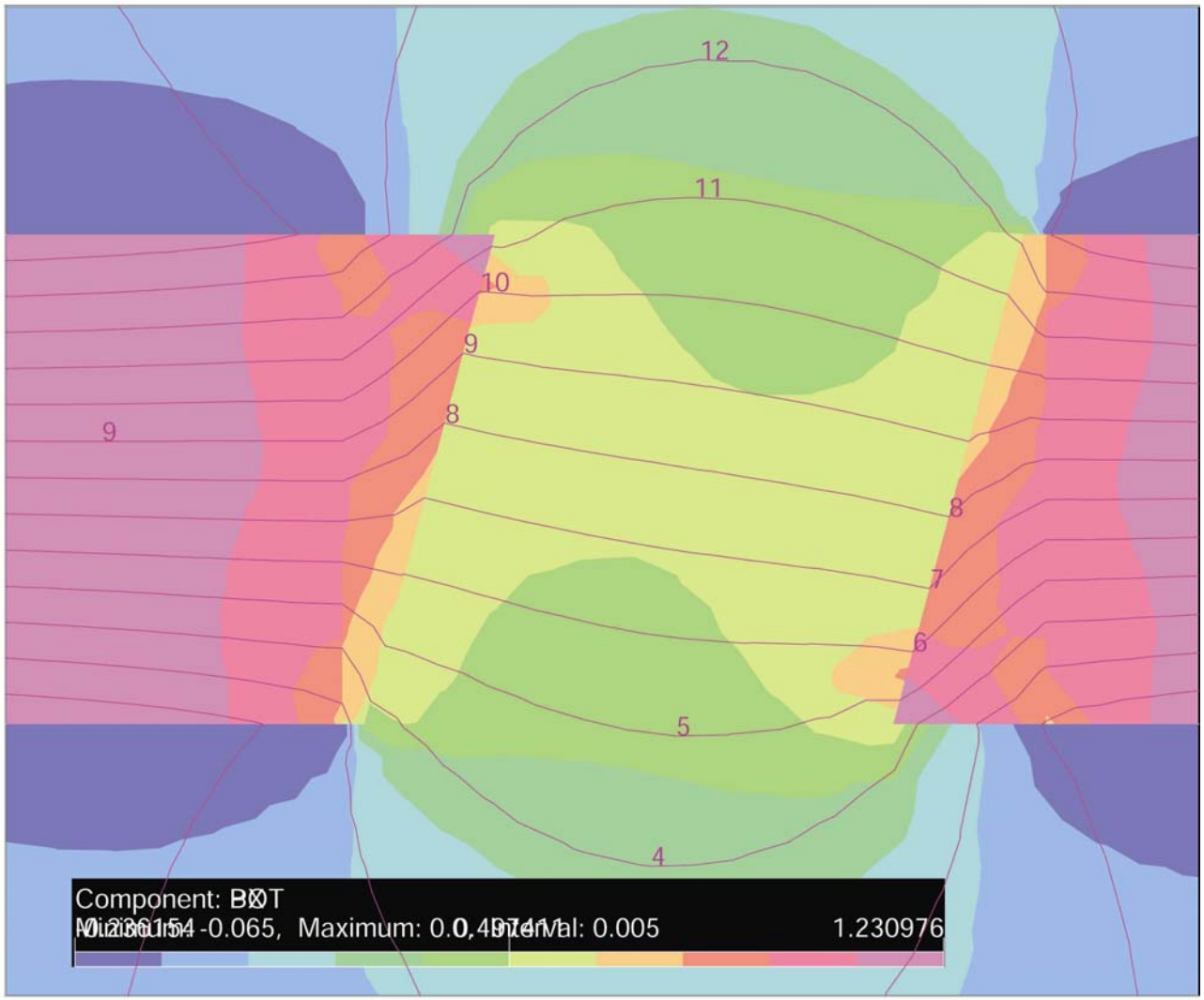
Magnet Geometry



Field in Magnet Gap



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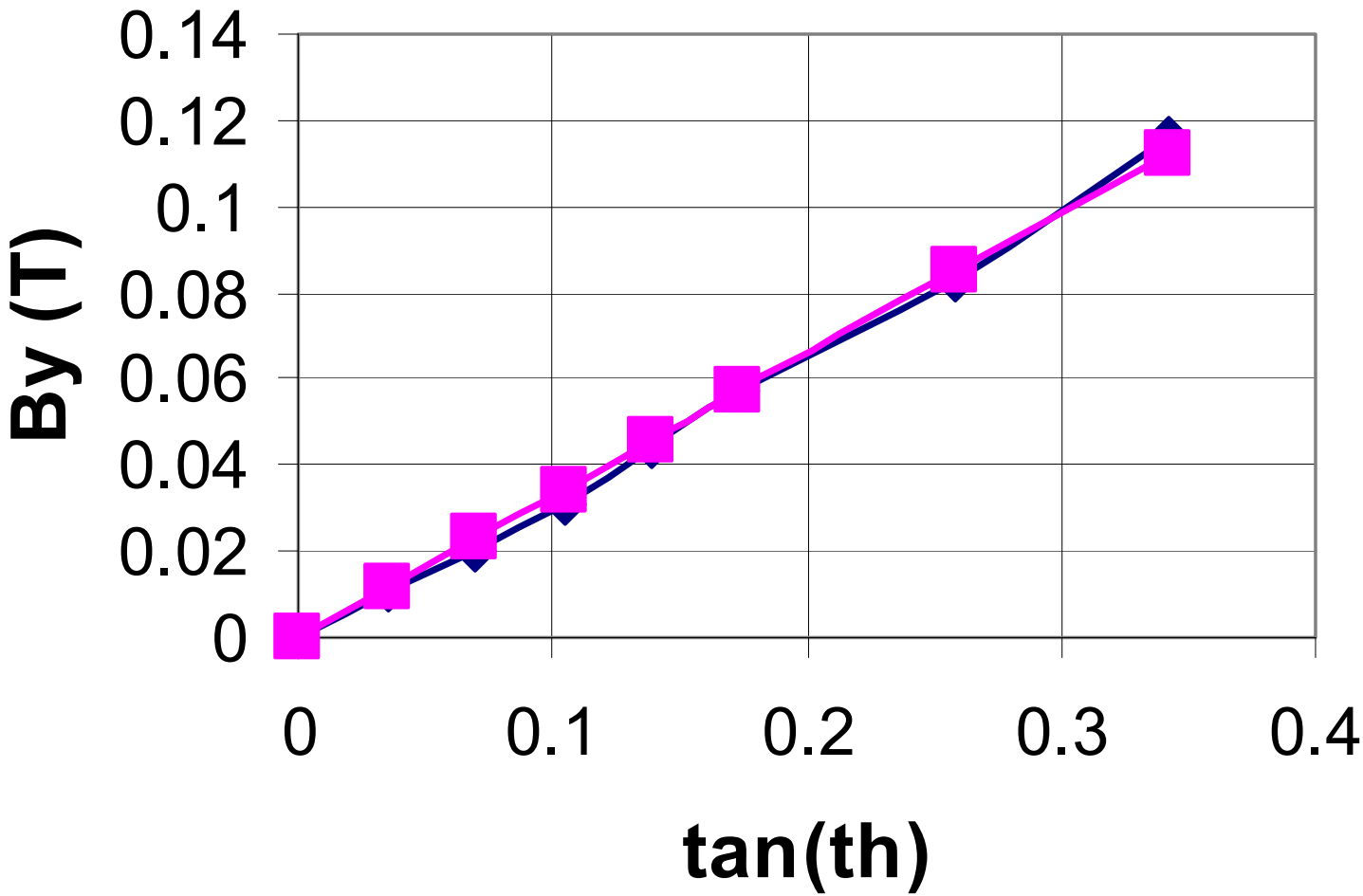
Correlation of Normal Field With Angle



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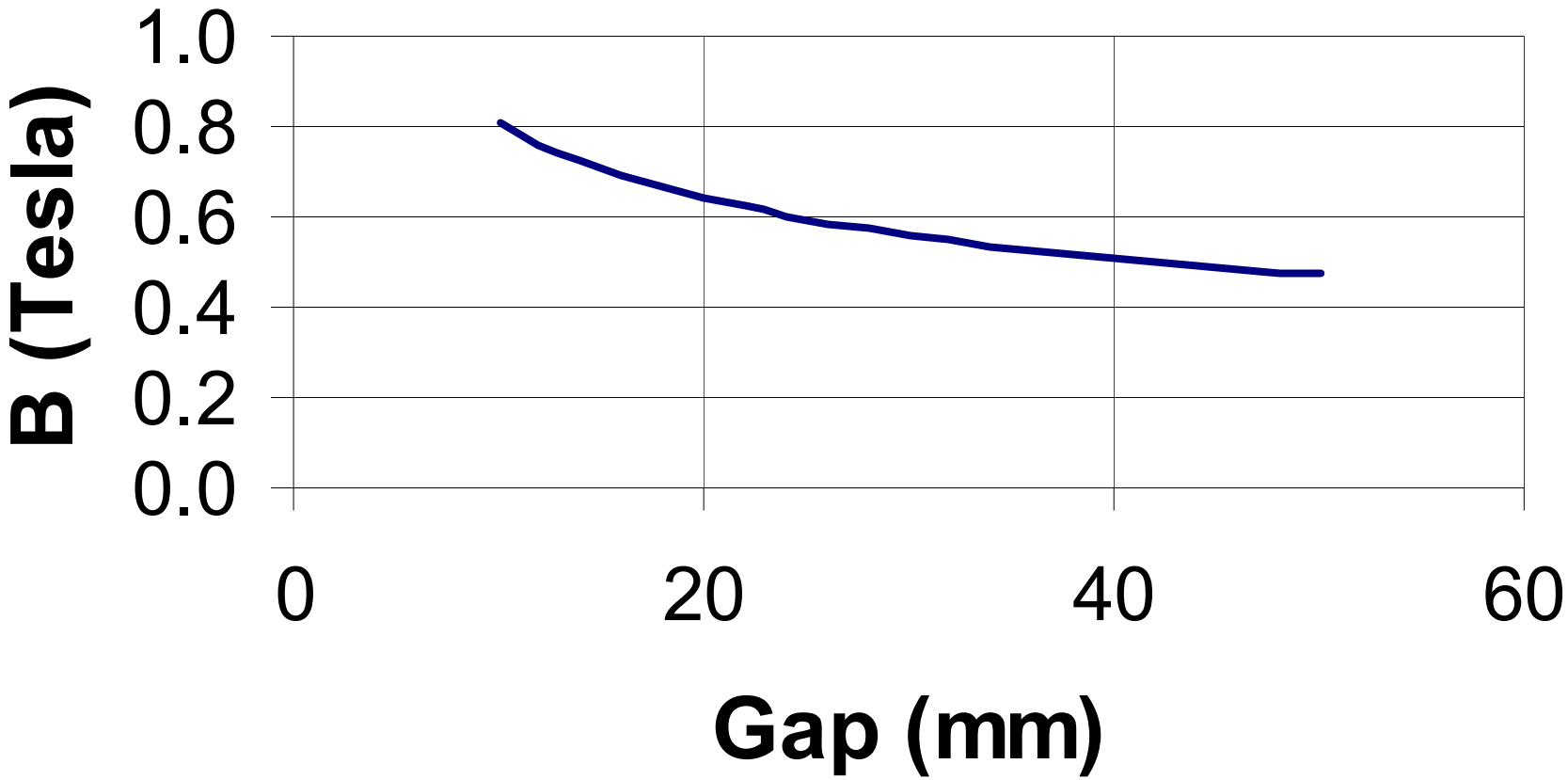
Field Versus Magnet Gap



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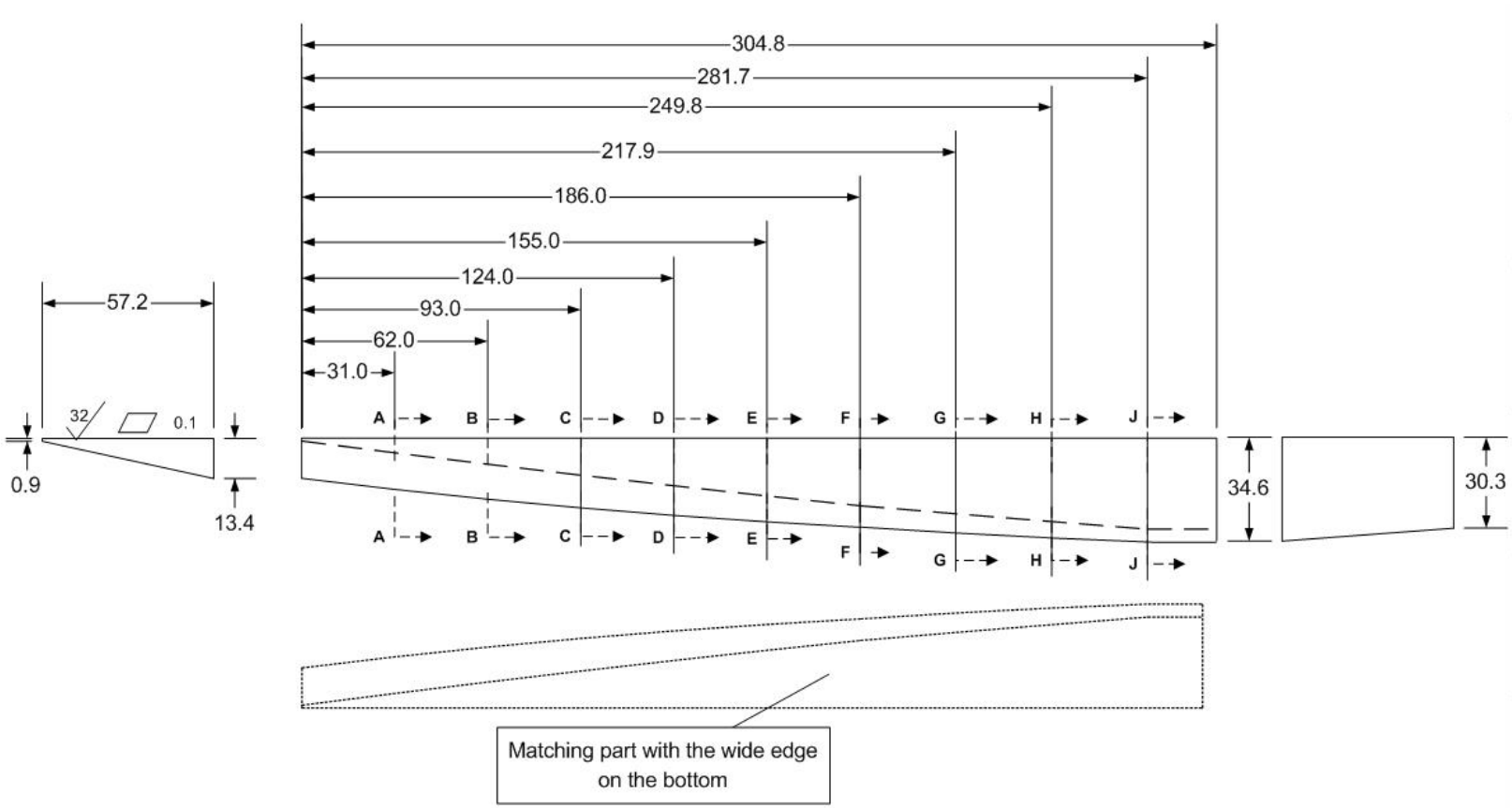
Pole Tip Design For NSTX



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Magnet Geometry Options

- Additional pole tips were designed for:
  - Uniform field
  - Just a gradient in the transverse field
  - Just a linear variation in the normal field
  - Reversal of the normal field
  - And others as needed
- Enough iron was purchased to make many more sets of pole tips

Status of Fabrication

- Vendor selected
- Purchase order placed in late March
- Iron delivery 4-6 weeks
- Fabrication about 6 weeks

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